such masses of air at different temperatures is to mix intimately and irregularly in order to restore the thermal equilibrium as rapidly as possible. The cold air is carried forward in the high levels, and like a sheet overflows the warmer lower layers, as is indicated by the first formation of clouds of the cirrus type, which later change into alto-cumulus and alto-stratus types.

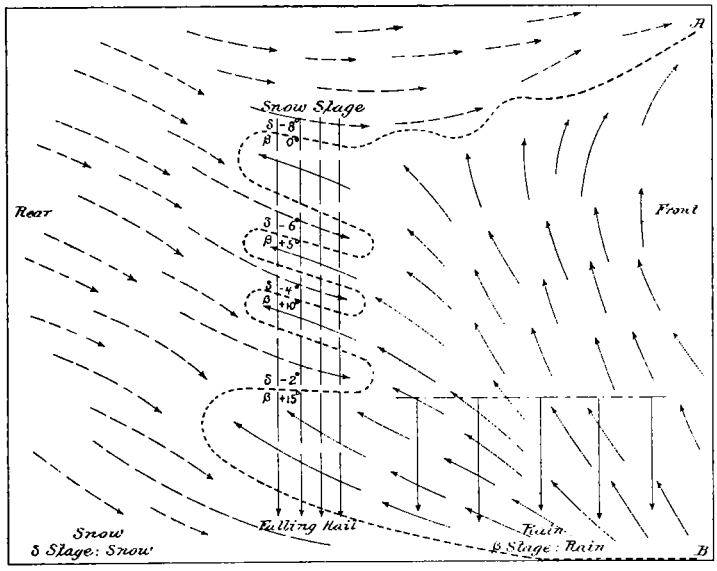

FIG. 40.—Stratification of β- and δ-stage in a cloud with hail.

The body of warm air tends to rise and interpenetrate the cold air in a congested circulation including numerous minor whirls and small vortices. On the western side of the column of rising warm air the tendency to stratification of the warm and cold layers in horizontal directions is very pronounced, the sheets of different temperatures penetrating strongly at a series of intervals in elevation, so that they lie over each other on a given vertical in succession which may be repeated many times. The boundary between the β-stage and the δ-stage, or the course of the γ-stage, is therefore folded upon itself several times in a vertical direction.

For example we may suppose that the temperatures are arranged in some such manner as the following:

Let $\beta = +15°$ C. and $\delta = -2°$ C. in the lowest fold;
let $\beta = +10°$ C. and $\delta = -4°$ C. in the second fold;
let $\beta = +5°$ C. and $\delta = -6°$ C. in the third fold;
let $\beta = +0°$ C. and $\delta = -8°$ C. in the fourth fold;

The temperatures in the β-stage fall off more rapidly than in the δ-stage, and the difference between them diminishes with the height.

The snow nucleus, starting from a great height, meets the water carried aloft in the warm strata, is coated with the drops, which are chilled by its lower temperature and frozen in irregular semicrystaline forms. The vertical current at even moderate velocities is able to carry up all the water contents in the form of drops, and they are injected as it were sideways from a fountain into the higher strata. The snow nucleus is therefore simply exposed to a spray of water drops, brought from the lower strata where high vapor contents prevail, because of the warm air occupying the lower levels before they were disturbed by the overflowing anticyclonic cold. The cold nucleus, therefore, suddenly condenses a layer of clear ice, or ice and snow when mixt by the minor vortices and horizontal rolling of the air. The small hailstone then falls by gravity thru successive stratifications of the snow and rain stages, it grows on the underside by special accumulations there, and finally reaches the ground, having received as many layers as there are distinct horizontal minor stratifications. The undercooling takes place chiefly in the highest stratifications, and ice or snow crystals are found deposited in the inner layers of the hailstone. The under cooling diminishes with the descent so that the outer layers are watery or simply opaque.

There evidently exists a series of small horizontal rolls produced by the dynamic action of the interflowing sheets, where the mixture of air at different temperatures is facilitated by drawing it out into thin ribbons, as in ordinary cyclonic circulations. The lowest cold stratum flows forward on the ground, producing the squall of cold air that precedes the rainfall. An examination of the isotherms and isobars on fig. 39 shows that this distribution of the air currents is the probable one, allowing for the minor configurations on the edges of the mixing masses. The isobars show that at the sea level the air flows forward, but in the upper levels it flows backward at the time of the hailstorm. The isotherms show that there is an excess of upward velocity at the line of separation, and also that the flow is backward in the higher levels. The production of lightning discharges under these conditions, especially in the region where the cloud is serrated as to temperatures, is evidently to be anticipated, in consequence of the rapid changes occurring in the thermal conditions and the water contents. The hailstones may therefore be heavily charged with positive electricity, or even with negative electricity, under these circumstances, and the fallen hailstones may exhibit electrical states by no means uniform from storm to storm.

It is desirable that numerous computations be made on the data that may be obtained from the surface observations in thunderstorms and in hailstorms, with the view of transforming our inferences regarding the thermal operations going on in the midst of such clouds into more definite knowledge. The formulas and the tables employed in this paper are satisfactory, and it is possible to accomplish much by using only our surface observations. It is, however, very important to supplement such studies with the actual observations in the clouds by balloons and kites.

CLIMATOLOGICAL REPORTS FROM THE PHILIPPINES.

The storm warnings, the publications, and other works that issue from the Philippine Weather Bureau show what an intense intellectual activity can be kept up by white men in a climate that is ordinarily supposed to be conducive to sluggishness and degeneracy. We never hear that the officials of the Manila Observatory need to leave their station occasionally in order to renew their mental and bodily vigor. They have been working on at the same rate for forty years past, and the great publications that they have lately issued seem to be due simply to the fact that more money has been put at their disposal for that purpose. The latest volume contains the complete record of two, four, or six observations daily of every ordinary meteorological element, in the year 1903, at forty-four stations, between the latitudes 6° 33′ and 20° 28′ N. and between the longitudes 119° 53′ and 126° 32′ E. All but one of these stations are near sea level, but that one, Baguio, is at 1456 meters elevation. Classified by orders we have: I, 7; II, 10; III, 20; IV, 7. With two exceptions, the observers seem to be Spaniards, and possibly members of the Jesuit order. The publications conform almost exactly to the requirements of the International Meteorological Committee. At the first and second class stations the hours of observation are 2, 6, and 10 a. m., 2, 6, and 10 p. m.; at the third and fourth class stations the hours are 6 a. m. and 2 p. m. At most stations the maximum and minimum temperatures are observed. The barometer readings are reduced to sea level, but the reduction to standard gravity seems to have been omitted, notwithstanding the advice of the International Committee and the general usage

of modern climatologists. A uniform standard of time is used, namely, that of eight hours east of Greenwich, which is, we believe, also the time shown by the time ball at the observatory for the use of the shipping. 8 a. m. at Washington is simultaneous with 9 p. m. of the same date at Manila. The record for a single month, at all 44 stations, occupies about 93 or 94 pages, and the twelve months, without an annual summary, make up an imposing volume of 1128 pages, from which one may see that the pages are not crowded with figures. This suggests the remark that considerable extravagance with regard to space and pages is shown in nearly all tabular matter that has hitherto been published under American auspices. We notice that in corresponding publications by European nations twice as much material is crowded into a single quarto page without destroying, but in fact increasing, the convenience with which one uses the data. Still it must be confest that very few nations have made their original daily records so accessible to climatologists as these of the Philippines, and we believe the result will be greatly to the advantage of these islands, since the superior attractiveness of their climates can now be more fully appreciated.

With this volume we receive also a copy of the Far Eastern Review, Vol. II, No. 13, for May, 1906, which is especially devoted to the Moro Province and the island of Mindanao. We owe this to the kindness of our former colleague, now Capt. John P. Finley, U. S. A., Governor of the District of Zamboanga and founder of the Moro Exchange at that place. As many of our readers are teachers of geography and climatology and will wish to do justice to these distant American possessions, we must refer them to this Far Eastern Review for details as to the climate and country. Brentano's (incorp.) is the American agency.

LUNAR RAINBOW AT TAMPA, FLA.

By J. S. HAZEN, Local Forecaster. Dated October 30, 1906.

A peculiar and interesting meteorological condition prevailed over this vicinity during the passage of a West Indian storm over the Gulf on October 1, 2, and 3. On October 1, from 8:30 to 10:30 p. m., fully eight-tenths of the sky was covered by a striated form of cirro-cumulus clouds, making a uniform banded appearance which was very striking. The appearance was much like the segments of a gigantic orange over portions of the sky. The bands were apparently about 10° in width at the zenith, decreasing somewhat toward the horizon, and were well defined and distinct from the intermediate spaces, which were apparently clear of clouds and of about the same width.

About 9 p. m. a brilliant and perfect lunar corona was observed, the prismatic colors being especially well defined, and running from purple to pale lavender. There was also a double row of concentric rings showing prismatic colors, outside the first corona. On the 2d and 3d of October lunar rainbows were observed, that on the 2d being especially brilliant and an object of much interest to many people in Tampa who saw it. A slight thunderstorm past west of the station early in the evening, and rapidly moving, massive cumulus clouds were drifting across the sky near the western horizon during the time the bow was noted.

The bow was a perfect arch, and showed all prismatic colors with remarkable distinctness. It reached at one time high above a large mass of cumulus clouds, showing with equal distinctness against the back ground of dark cumulus clouds and the apparently clear sky above the cloud. Stars could be seen thru the bow with brilliancy very little diminished, if any. Both phenomena were observed by many in this city. It is understood that a lunar rainbow was observed in Pensacola also about this time.

The lunar rainbow is such an unusual occurrence that the writer would be pleased to have editorial comment pertaining to meteorological conditions necessary for the display of such phenomena, and whether or not the passage of a West Indian storm would bring about meteorological conditions likely to result in such phenomena.

It occurs to the writer that certain extensive movements of the upper air must be necessary to result in such a condition as was observed here on the dates mentioned.

EDITORIAL.—On the evening of October 1 the above-mentioned storm center was two or three hundred miles northwest of Tampa, and whatever the local winds may have been at that place the general drift of the atmosphere above it seems to have been from the south and east. This upper current was not necessarily at any great elevation, and below it was the usual layer, a few thousand feet in thickness, of relatively quiet air. Under these conditions a series of atmospheric waves, each of them many miles in length and possibly a mile or two in breadth, is usually formed.[1] The upper portion, or crest, of each billow becomes visible by a little cloudy condensation, while the lower portion is formed of relatively clear air. These crests and troughs must have extended eastward and westward in this case, or perhaps northeastward and southwestward, over Tampa, in parallel lines toward the distant horizon, and the observer, looking upward, should have seen them by perspective tapering toward the two opposite vanishing points, and covering the sky with markings analogous to the gores of a gigantic balloon. The width of each gore, or band, is stated by Mr. Hazen to have been about ten degrees at the zenith, and if the clouds were five or six thousand feet above him, this would correspond to about one thousand feet in linear distance.[2] If we knew the exact height and width of the billows, we could compute approximately the velocity of the wind at that elevation.

A corona, or glory, is formed by light shining thru a layer of small particles, such as dust, or fog, or crystals (spiculæ) of ice. If the observer had given the diameters of some of the rings of color composing the corona, something could have been inferred about the size and shape of these particles; but the fact that he does not mention the size, nor state whether the purple rings were inside or outside of the lavender rings makes it difficult to decide whether we have to do with a corona or a halo.

On the 2d and 3d of October lunar rainbows were observed. These require the presence of drops of water of appreciable size, and are not especially rare, but it is interesting to notice that they occurred apparently long after the passage of a slight thunderstorm on the 2d, and again quite independently of any rain on the 3d. The drops needed to form the lunar rainbows must, therefore, have been thinly scattered thru the clear air and may have evaporated in falling to the ground.

The passage of a West Indian hurricane is believed not to be necessary as preliminary to the appearance of such rainbows and coronas, and we hope that several of the observers in Florida will give us statistical studies of the relations between storms and halos, coronas and rainbows, based upon the records of their respective stations.—*C. A.*

THE ORIGIN OF OUR COLD WAVES.

It has for a long time been desirable to obtain observations and daily maps that would throw light upon the rival hypotheses as to the origin and nature, or the mechanics, of the areas of high pressure and cold, dry air that descend from the northwest, north, and sometimes the northeast upon the United States.

According to one, these are due to upper westerly winds blowing over the Rocky Mountains toward areas of low pressure. The air becomes clear and dry as it descends the eastern

[1] See Helmholtz on "Atmospheric Motions," translated in "Mechanics of the Earth's Atmosphere."

[2] One degree is 1/57.3 part of the radius.